THE ECOLOGY OF *SALVINIA AURICULATA* AND ASSOCIATED VEGETATION ON KARIBA LAKE

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(With Plate XXVI)

ABSTRACT

The populations of *Salvinia auriculata* on Kariba Lake are thought to have originated from plants carried down the Zambesi River from older populations occurring upstream from the Victoria Falls. The phenomenal spread of Salvinia in the Lake was favoured by the sheltered habitats provided by the large areas of partly submerged trees. Compacted Salvinia mats have been invaded and bound chiefly by *Scirpus cubensis*.

INTRODUCTION

Salvinia auriculata Aubl. is a floating aquatic fern often grown as an ornamental plant in tropical fish tanks and ponds. It is indigenous to South and Central America and the larger Caribbean islands. Within recent years, this species of Salvinia has become notorious for its extremely rapid vegetative reproduction over areas of still fresh water in tropical and subtropical regions to which it has been introduced. In Ceylon, it is estimated to have spread over 22,000 acres of rice fields and over 2,000 acres of waterways in twelve years. (Williams, 1956.)

In contrast, *S. hastata* Desv., which is endemic to Madagascar and East Africa from Mozambique northwards to Kenya, is a much less rampant grower. It is readily distinguished from *S. auriculata* by the absence of the four-celled, basket-like structures surmounting the leaf papillae, a feature characteristic of *S. auriculata*. (Herzog, 1935.)

The plant body consists of a fragile horizontal stem with an apical growing point and with a pair of floating leaves and a finely dissected submerged leaf at each node. In habitats where the plants are not crowded on open water, the floating leaves of *S. auriculata* are flat and do not overlap. However, when the plants become restricted for space, the floating leaves become folded along the midrib and stand suberect, closely set together. Sporocarps have only been observed on such compact forms and it appears that some factor associated with crowding is responsible for inducing sporocarp formation.

In South Africa, colonies of *S. auriculata* are known from the Cape Flats (Adamson, 1950), Gouna and Ruigtevlei in the Knysna area, and the species has been reported recently from the Baakens River in the Port Elizabeth district and from Ottos Bluff near Pietermaritzburg, Natal. The colony at Gouna, in a small pond near the forester's office, produces abundant sporocarps wherever the plants are closely compacted. In the Rhodesias, colonies of Salvinia have been known to occur in the backwaters of the Zambesi River, upstream from the Victoria Falls as far as Kazungula, for at least ten years. Within the last five years this Salvinia has appeared on open water in the Umtali and Rusapi districts as well as spreading rapidly on the newly formed Kariba Lake. Dr. H. Wild has also observed it growing in the spray zone of the Victoria Falls "rain" forest where it is perpetually drenched but not growing as a floating aquatic. All the Rhodesian material seen as yet is *S. auriculata.*

ORIGIN AND DEVELOPMENT OF SALVINIA POPULATIONS ON KARIBA LAKE

The presence of small patches of Salvinia on Kariba Lake was first reported in May, 1959, when the water level in the area had begun to rise. In view of the fact that *S. auriculata* had long been established on the Zambesi River above the Victoria Falls, it seems most probable that the population on Kariba Lake originated from plants carried over the Falls and downstream to Kariba. It is thought that the small and very buoyant plant body of Salvinia would enable it to survive carriage over the Falls and the passage through the turbulent waters of the Zambesi in the gorges below the Falls.

It is very probable that before the construction of the Kariba Dam, viable pieces of Salvinia, originating from the upstream colonies, were being carried over the Falls intermittently into the lower reaches of the Zambesi. However, if any such Salvinia plants formed a small colony in a quiet backwater it would most probably be flushed out of such a riverine habitat by periodic floods.

The construction of the Kariba Dam brought about a lacustrine habitat with an increasing area of water available for colonisation by floating aquatic plants and a corresponding decrease in the flushing effect of periodic floods. The stability of the new water surface was further enhanced by the gradual submergence of fairly closely spaced trees, whose partly submerged crowns damped wave action and reduced wind velocity about the water surface. It can also be expected that a significant increase in the nutrient level of the water would have occurred.

The development of large areas of sheltered water surface among partly submerged tree crowns favoured the explosively rapid vegetative reproduction of *S. auriculata* on the Lake during the spring of 1959.

In April, 1960, thirteen months after the plant was first reported from Kariba, the author estimated that the Salvinia mats covered an area of approximately 75 sq. miles. The estimate is based on a sketch map made of these mats during aerial reconnaissance of the Lake (Fig. 1). Recent reports indicate that in the twelve-month period subsequent to the author's visit, the Salvinia mats have extended to cover over 200 sq. miles of the surface of the Lake.

In April, 1960, the Salvinia mats were found to be almost confined to the upstream half of the Lake. Most of these mats occurred along the shoreline but a few discrete patches were observed on otherwise open water in the middle of the Lake. The comparatively low incidence of Salvinia between the Sengwe River estuary and Kariba at that time could have been due to the prevailing east to north-easterly winds checking downstream migration of Salvinia mats.

FREE-FLOATING SALVINIA MATS

Although it is postulated that the explosive spread of Salvinia in the spring of 1959 was favoured by the relatively sheltered habitats provided by partly submerged tree crowns, large populations observed in April, 1960, were floating free of any submerged trees. These free-floating Salvinia mats were often strikingly heterogeneous in that patches of old, sun-scorched, compacted, fertile Salvinia with sporocarps were distributed through a mat of much less compacted greener plants in the vegetative phase. As it is known that the compacted fertile form only occurs under conditions of crowding, it seems very probable that the free-floating mats are continually breaking up and re-forming. The small patches of sun-scorched, compacted fertile plants could well have originated from crowded colonies in sheltered estuaries which were partly broken up by floods in those tributaries. Alternatively, relatively old compacted colonies could have floated free of previously half submerged tree crowns as the water level rose.

There is some evidence that free-floating Salvinia mats are moved downstream by floodwaters entering the Lake. At the arrival of the "Barotse floods" during the author's visit, the passage between the Maze and Masumo Rivers was almost covered by an extensive Salvinia mat. On the return cruise twenty hours later the passage was almost clear of Salvinia at this point but a similar newly formed mat covered the passage a quarter of a mile downstream. During the aerial reconnaissance carried out shortly afterwards, down-current "tails" to mid-lake Salvinia colonies were observed, a phenomenon probably caused by surface downstream currents associated with these floodwaters.

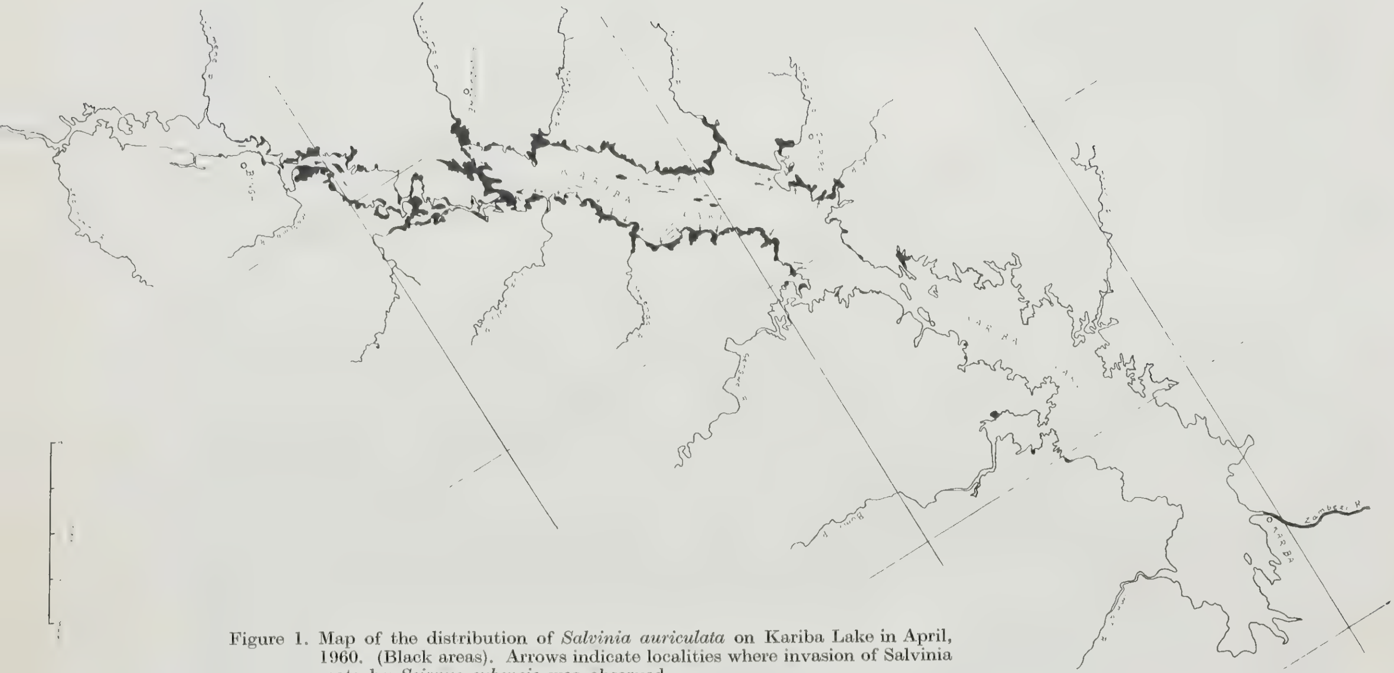
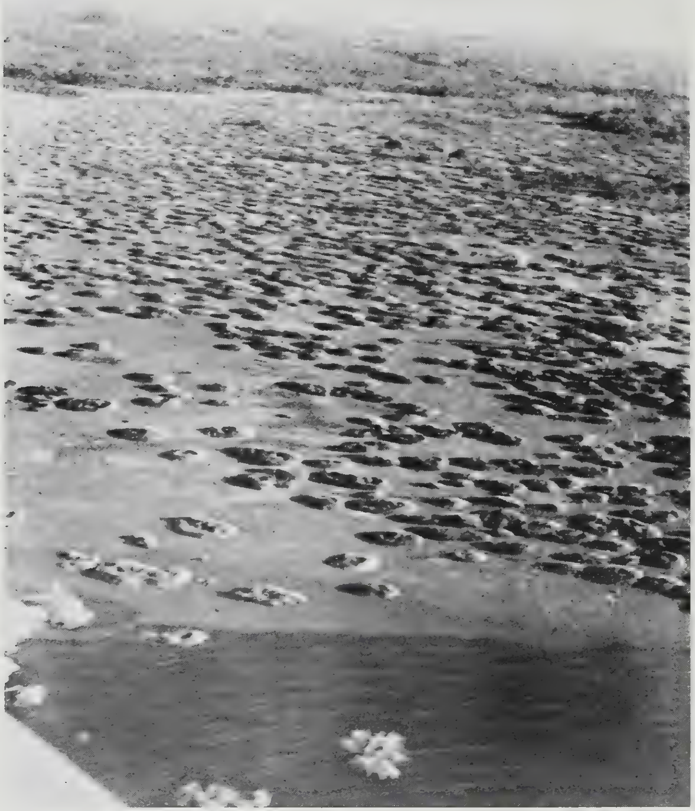


Figure 1. Map of the distribution of *Salvinia auriculata* on Kariba Lake in April, 1960. (Black areas). Arrows indicate localities where invasion of Salvinia mats by *Scirpus cubensis* was observed.



Aerial photograph of a partly stabilised Salvinia mat with domed colonies of *Scirpus cubensis* near the Luzilukulu River estuary. An emergent tree crown shows above the open water in the foreground. The wooded shoreline can be seen in the distance.

In the central third of the Lake, the free-floating Salvinia mats contained a well dispersed but relatively small number of plants of *Pistia stratiotes* L. and small colonies and individual young plants of *Scirpus cubensis* Poepp. & Kunth. Upstream from Binga, Salvinia was much less prominent or absent. However, in this uppermost portion of the Lake a few colonies of the aquatic grass *Vossia cuspidata* Griff. were found in mid-lake while *Pistia stratiotes* formed almost pure colonies among half submerged trees along the shore near the Chimene River estuary. Other aquatic plants observed in this part of the Lake included *Ceratophyllum demersum* L., *Lemna sp.*, *Utricularia stellaris* L.f. and *Utricularia thonningii* Schumach.

As a lack of protection from wind and wave action on the future of floating aquatic vegetation on the Lake could be of some economic consequence, the apparent effects of these factors on Salvinia and its associated species were noted after a storm on the Lake. The Salvinia exhibited no signs of damage but isolated plants of *Pistia* and *Scirpus cubensis* not associated with Salvinia mats had been blown over and slightly damaged.

STABILISED SALVINIA MATS

The greater part of both shorelines in the upper half of the Lake, from about the Sengwe River estuary to Binga, is lined with Salvinia mats which are more or less stabilised by the emergent branches of partially submerged trees. These mats vary considerably in the degree of compaction of the Salvinia plants. In more recently formed colonies the plants are only one layer thick. However, in some sheltered estuaries the Salvinia mats appear to have been undisturbed for a relatively long period and consist of several layers of compacted plants forming mats up to 15 cm. thick. The plants in such thick mats are usually sunscorched and bear abundant sporocarps. Where the crowns of taller trees still stand above water, accumulations of fallen leaves lie on the mats under such emergent tree crowns. Stabilised mats are usually bordered on their lakeward margins by fringes of younger, greener Salvinia in the vegetative phase or by free-floating mats of varying widths.

An important biological phenomenon associated with the occurrence of thick Salvinia mats that have remained undisturbed for some time is the low oxygen content of the water below them. For example, in the Zongwe River estuary under such a mat, oxygen contents of the water near the surface and at a depth of one metre were 0·64 and 0·66 mg./l., respectively, as compared with 4·4 to 6·9 mg./l. in open water. Thus under undisturbed mats oxygen contents are close to the minimum oxygen requirements of some fish. Under thin, younger or disturbed mats oxygen contents of the water approach levels found in open water. Consequently the degree of deoxygenation seems to be related to the thickness of the mats and the period during which they have not been disturbed.

SUCCESSION ON STABILISED SALVINIA MATS

It has already been noted that free-floating Salvinia mats contain numbers of scattered individuals and small colonies of *Scirpus cubensis*. At various points along the shorelines in the central part of the Lake, stabilised Salvinia mats were being rapidly colonised by this Scirpus in April, 1960. This sedge sends out horizontal stolons among the spongy mass of submerged Salvinia leaves and produces leafy shoots at intervals along them. Eventually dome-shaped colonies are formed which may be scattered throughout the Salvinia mat (Plate I) or form a closed community a hundred metres wide, as was found between the Masanga and Chimburu Rivers.

A number of other aquatic angiosperms were also observed colonising and binding stabilised Salvinia mats. In the Chezia River estuary, a number of large plants of *Ludwigia adscendens* (L.) Hara were found sending out horizontal stems, over six metres long, which were rooting into the Salvinia mats. Other species which were also invading stabilised mats in this and other localities included *Ludwigia leptocarpa* (Nutt.) Hara, *Polygonum senegalense* Meisn., the grasses *Panicum repens* L. and *Echinochloa pyramidalis* (Lam.) Hitchc. & Chase, a species of Commelina and an unidentified sedge.

Although it was apparent that the invasion of the stabilised Salvinia mats was still in the early stages at the time of the author's visit, some of the larger Scirpus colonies appeared to have collapsed centres (Plate I). Unfortunately this phenomenon was only observed from the air and could not be investigated at close quarters.

It is possible that the succession will not proceed further when the Salvinia-Scirpus mats float clear of any submerged trees as the water level in the dam rises. Also, when the dam is full, it can be expected that offshore areas with partly submerged trees will support floating aquatic vegetation and that the succession in such areas will proceed at least to a closed Scirpus community. However, the recording of the further development of the aquatic vegetation on the Lake must be left to future investigators.

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References

Adamson, R. S., 1950. Pteridophyta in Flora of the Cape Peninsula. Cape Town.

Herzog, R., 1935. Ein Beitrag zur Systematik der Gattung Salvinia. Hedwigia, **74** : 257–284.

Williams, R. H., 1956. *Salvinia auriculata* Aubl.; the chemical eradication of a serious aquatic weed in Ceylon. Tropical Agriculture, **33** : 145–158.